Original Article

Effect of central adiposity on lung function tests in adolescents

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ABSTRACT

Objectives: The objectives of the study were to study the relation of total body adiposity and abdominal adiposity markers with forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC) in adolescents in Bengaluru. **Methods:** 125 healthy children from a school and 70 asthmatics from Ramaiah hospital between 10 and 15 years were included in the study. Anthropometry including weight, body mass index (BMI), waist and hip circumference, and abdominal height was done in all study adolescents. The subjects were categorized according to BMI. Pulmonary function tests (PFTs) were done by Knudson method and FEV1, FVC, and peak expiratory flow (PEF) were measured. The patients were classified by their asthma severity according to GINA guidelines. **Results:** BMI, weight, waist and hip circumference correlated with abdominal height in male asthmatics and controls where they revealed significant correlations with FEV1/FVC% ratio. In females, abdominal height correlated with BMI, weight, waist and hip circumference in both the groups. PEF correlated with BMI, weight, waist circumference, and abdominal height in healthy females. FEV1/FVC correlated with BMI, abdominal height in female asthmatics, with weight in healthy females. Independent predictors of FEV1/FVC% ratio were hip circumference in males and abdominal height, and waist circumference in females. **Conclusion:** Increase in obesity is associated with reduced lung volumes and flows. The abdominal adiposity markers (waist and hip circumference, and abdominal height) are significant and effective predictors of obesity and the variations of PFT's than total adiposity markers (BMI and weight).

Key words: *Central obesity, BMI, Pulmonary function tests*

There is increase in the prevalence of asthma globally as well as in Bengaluru due to increasing urbanization and increasing triggers for asthma [1,2]. In addition, obesity is showing a rise in the curve among urban population [3,4]. Several studies have established obesity as being associated with respiratory complications such as asthma, obstructive sleep apnea, obesity hypoventilation syndrome, diabetes, and coronary heart disease [5,6].

Body mass index (BMI) has been widely used to predict the lung function. However, the exact relation between the abdominal obesity markers such as waist and hip circumference, abdominal height and waist-hip ratio and pulmonary function parameters among Indian pediatric population is not known. In this study, we investigated the predictability of total body adiposity and abdominal adiposity with forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC) in adolescents in Bengaluru, India. We hypothesized that a greater accumulation of abdominal fat is associated with lower levels of FEV1 and FVC, and that abdominal adiposity is a better predictor of reduced pulmonary function than the total body adiposity.

MATERIALS AND METHODS

This case-control study was conducted in the pediatric department of a tertiary care teaching hospital over a period of 3 years. 125 healthy normal adolescents from a school in Bengaluru and 70 asthmatic adolescents from M. S. Ramaiah hospital within the age group of 10-15 years were included in the study. Cases and controls were matched for age. Inclusion criteria were all healthy children and children diagnosed as asthmatic at least 6 months ago in age group of 10-15 years. Exclusion criteria were children with acute chest infection or upper respiratory tract infection, chronic liver disease, systemic collagen diseases, anemia, heart failure, and any other cardiopulmonary diseases. The informed consent from parents and consent of the adolescents was taken. Consent from the head of the school was also taken for adolescents recruited from school.

Demographic details and exposure to the triggers of asthma were filled in the questionnaire. Past treatment details of asthmatic adolescents were also noted. Thorough clinical examination was done and anthropometric measurements were recorded. Measurement was done as standing for weight (digital scales) and height (stadiometer) and BMI was calculated. Waist and hip measurements were taken with a nonstretchable tape. Waist circumference was measured at the narrowest circumference between the bottom of the ribcage and the iliac crest while the patient standing with the abdomen relaxed, at the end of a normal expiration. The measurement was taken at the level of the umbilicus when there is no natural waistline. Hip circumference was measured at the maximum circumference between the iliac crest and the symphysis pubis while standing. Waist/hip ratio was then calculated as waist circumference divided by hip circumference.

Abdominal height is defined as the sagittal diameter of the abdomen measured at the iliac crest in supine position. The sagittal diameter of the trunk was measured, with subjects in the supine position, as the vertical distance between a firm examination table and a carpenter's level kept horizontally across the abdomen at the height of the iliac crest. We refer to body weight and BMI as the total adiposity markers and abdominal height, waist circumference and waist/hip ratio as abdominal adiposity markers. The subjects were categorized according to BMI based on Indian Academy of Pediatrics charts [7]. Pulmonary function tests (PFTs) were done by Knudson method using micro lab 3000 spirometer with the patient breathing room air. FEV1, FVC, and PEF were measured. The best of 3 measurements obtained was used to calculate the FEV1%, FVC%, FEV1/FVC%, and peak expiratory flow (PEF%). The patients were classified by their asthma severity according to GINA guidelines.

The sample size was obtained using n-master software based on the study "abdominal and total body adiposity markers in asthmatic patients [8] considering the correlation coefficient between waist circumference and asthma severity (r=0.4). Considering 5% as alpha error and keeping the power of study at 80%, number of the sample studied was worked out to be 66. However, 70 cases and 125, i.e., nearly 1:2 controls were recruited.

RESULTS

All 70 (male 41, female 29) asthmatics were mild persistent asthmatics. In the control group of 125 healthy nonasthmatics, males were 77 and females were 48. Table 1 shows the demographic data of all the 195 participants of the study. In males, BMI was >85th centile in 11 healthy adolescents and 5 asthmatics. 30 healthy and 22 asthmatics in males were in 5-50th centile. In females, BMI was >85th centile in 8 healthy adolescents and 2 asthmatics. 12 healthy asthmatics and 8 asthmatics in females were in 5-50th centile.

All the 5 variables, *viz.,* BMI, weight, waist and hip circumference, and abdominal height revealed significant correlations with FEV1/FVC% ratio among all male adolescents. PEF and FEV1 did not correlate significantly. BMI, weight, waist and hip circumference correlated well with abdominal height in both the male asthmatics and controls (Table 2). In females, FEV1/FVC ratio correlated with BMI and abdominal height in asthmatics and with weight in nonasthmatics. PEF correlated with BMI, weight, waist circumference, and abdominal height in healthy children. FEV1 correlated with weight in female asthmatics significantly. BMI, weight, waist and hip circumference correlated well with abdominal height in both female asthmatics and controls (Table 3).

Table 1: Demographics of study participants

Father	Smoking	Yes	38
		No	157
Mother	Smoking	Yes	0
		No	192
Family history of asthma	Yes		6
	No		189
Previous history of asthma	Yes		70
	No		125
When were they diagnosed as asthmatic	<6 months		0
	6-12 months		40
	>1 year		30
How often are symptoms	Always		6
	Rarely		38
	No		26
When are symptoms more	Day		31
	Night		39
Limitation of physical activity due to asthma	Yes		7
	No		63
No of days of school missed in an year due to asthma (days)	1-5		10
	5-15		44
	>15		16
Medicines used for asthma	Inhalers		61
	Others		9
How often medicines are used	Daily		4
	3-4 times weekly		14
	Only on symptoms		52

The results of multiple regression analysis revealed only hip circumference as an independent predictor of FEV1/FVC ratio (Table 4). Other variables failed to attain statistical significance. Among females, both abdominal height and waist circumference were found to be independent predictors of FEV1/FVC ratio and R^2 accounted for a value of 44.7%.

DISCUSSION

Weight and BMI as measures of overall adiposity are used as predictors of pulmonary function in many epidemiologic studies. While these measures are widely accepted as determinants of pulmonary function, abdominal adiposity may affect the pulmonary function through a mechanism that is different from that of overall adiposity. The exact relation between the abdominal obesity markers such as waist and hip circumference, abdominal height and waist-hip ratio among Indian pediatric population is not known. In our study, in male adolescents, increase in waist and hip circumference correlated positively with increase in BMI.

Table 2: Corelation coefficient (r) between different variables in male asthamatics and controls

Variables	PEF-A	PEF-NA	FEV1-A	FEV1-NA	FEV1/FVC-A	FEV1/FVC-NA	Abdominal height-A	Abdominal height-NA
BMI								
r	0.016	−0.054	0.174	0.115	−0.350	−0.435	0.811	0.717
P	0.922	0.643	0.276	0.320	0.025	0.000	0.000	0.000
Weight								
r	0.076	0.010	0.184	0.111	−0.346	−0.495	0.742	0.705
p	0.636	0.932	0.249	0.336	0.027	0.000	0.000	0.000
Waist circumference								
r	0.031	−0.101	0.047	−0.074	−0.406	−0.444	0.713	0.737
P	0.846	0.383	0.771	0.523	0.009	0.000	0.000	0.000
Hip circumference								
r	0.083	−0.105	−0.019	−0.046	−0.516	−0.439	0.677	0.657
P	0.605	0.362	0.904	0.691	0.001	0.000	0.000	0.000
Abdominal height								
r	0.105	−0.023	0.069	000	−0.512	−0.330	1	1
p	0.515	0.842	0.670	0.997	0.001	0.003		

BMI: Body mass index, PEF: Peak expiratory flow, FEV1: Forced expiratory volume in the first second, FVC: Forced vital capacity

Table 3: Corelation coefficient (r) between different variables in female asthamatics and controls

Variables	PEF-F-A	PEF-F-NA	FEV1-F-A	FEV1-F-NA	FEV1/FVC-F-A	FEV1/FVC-F-NA	Abdominal height-A	Abdominal height-NA
BMI								
r	0.064	−0.415	0.211	−0.073	−0.397	−0.217	0.906	0.857
p	0.743	0.003	0.272	0.620	0.033	0.138	0.000	0.000
Weight								
r	0.270	−0.375	0.384	0.009	−0.051	−0.277	0.732	0.743
p	0.157	0.009	0.040	0.950	0.791	0.057	0.000	0.000
Waist circumference								
r	0.100	−0.316	0.171	−0.036	−0.135	−0.109	0.821	0.900
p	0.606	0.029	0.376	0.810	0.485	0.462	0.000	0.000
Hip circumference								
r	0.199	−0.166	0.273	0.107	−0.019	0.119	0.706	0.702
p	0.300	0.259	0.151	0.468	0.924	0.422	0.000	0.000
Abdominal height								
r	−0.040	−0.387	0.042	−0.053	−0.484	0.041	1	1
p	0.836	0.007	0.829	0.721	0.008	0.783		

BMI: Body mass index, PEF: Peak expiratory flow, FEV1: Forced expiratory volume in the first second, FVC: Forced vital capacity

Table 4: Logistic regression analysis

Sex	Model	R	R^2	Adjusted R^2	Standard error of the estimate	Change statistics	
						R^2 change	F change
Male	1	0.516[a]	0.266	0.247	11.779	0.266	14.146
Female	1	0.484[b]	0.235	0.206	12.099	0.235	8.275
	2	0.668[c]	0.447	0.404	10.481	0.212	9.975

[a]Predictors: (Constant), hip circumference (cm), [b]Predictors: (Constant), abdominal height (cm), [c]Predictors: (Constant), abdominal height (cm), waist circumference (cm)

Furthermore, FEV1/FVC ratio decreased as abdominal obesity increased. Similar results were obtained in female adolescents who were obese. Similar results were also obtained in a study conducted in adults by Lazarus et al. [9].

There was a significant decrease in FEV1/FVC ratio with increase in waist and hip circumference in this study. We found a negative association of abdominal adiposity and pulmonary function in adolescents in healthy controls that were not limited to severely obese persons. This indicates that abdominal obesity also produces some restriction even in non-asthmatics. Therefore, abdominal obesity markers such as waist and hip circumference can be used in place of BMI in adolescents in whom fat distribution is mainly in the trunk. BMI should be interpreted with caution in adolescents [10].

In the study by Spathopoulos et al. [11], the effect of increased BMI on asthma was significant in girls but not in boys. A study by Paralikar et al. [12] showed that lung function impairment, particularly, decreased MVV and reduced FEV1/FVC ratio, was associated with obesity in adolescence. In addition, pulmonary functions deteriorate with increasing obesity in adolescence and correlate negatively with various indices of obesity, viz., weight, BMI, waist and hip circumference, and waist-to-hip ratio. Obesity may directly affect respiratory function through various mechanisms. It is possible that abdominal adiposity limits lung expansion compared to overall adiposity, which may partially compress the chest wall. The accumulation of fat may mechanically affect the expansion of the diaphragm and may restrict the descent of the diaphragm [13,14]. Fat deposits between the muscles and the ribs may also decrease chest wall compliance.

A lot of data emerging about the relationship between obesity and asthma suggest obesity increasing an individual's risk of developing asthma. Recent investigations toward elucidating a shared genetic basis for these two disorders, obesity and asthma, have identified polymorphisms in specific regions of chromosomes 5q, 6p, 11q13, and 12q. Each of these locations contains one or more gene encoding receptors relevant to asthma, inflammation, and metabolic disorders [15,16]. Further investigations are required to understand whether this environment alters the asthma risk or phenotype.

Strengths of our study are that we considered all the central adiposity markers. These parameters can be easily obtained bedside and do not need expensive equipment. The power of the study is good as nearly 1:2 controls were recruited. Limitations of the study were that the findings were based on the cross-sectional analyses. An interventional study is necessary to confirm the actual improvement of respiratory function after reduction of abdominal obesity. The second limitation is that we did not assess puberty staging as hormonal differences before and after puberty may affect the relation among gender, obesity, and asthma.

CONCLUSION

Increase in the obesity is associated with reduced lung volumes and flows. The abdominal adiposity markers as waist and hip circumference and abdominal height are more significant and effective predictors of obesity and the variations of PFT's than total adiposity markers (weight and BMI).

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